Cat

W. D. Walcott.

Preliminary Notes

ON THE

Occurrence of Serpentine and Talc

AT

Easton, Penna.

F. B. PECK

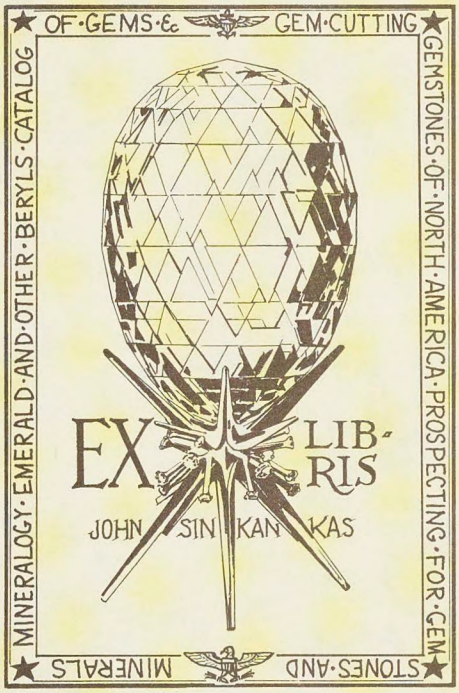
PLATE XVI; TEXT FIGURES 4, 5

[Reprinted from ANNALS N. Y. ACAD. SCI., Vol. XIII., No. 6, pp. 419-430, January 14, 1901.]

LANCASTER, PA.
THE NEW ERA PRINTING COMPANY
1901

Smithsonian Institution
Geol
National Museum.

Ack


OF·GEMS·&c
GEM·CUTTING
GEMSTONES·OF·NORTH·AMERICA·PROSPECTING·FOR·GEM
STONES·AND
MINERALS
MINERALOGY·EMERALD·AND·OTHER·BERYLS·CATALOG
EX
LIB-
RIS
JOHN
SIN
KAN
KAS

JSL
RTL013301

[Annals N. Y. Acad. Sci., Vol. XIII, No. 6, pp. 419–430, Jan. 14, 1901.]

PRELIMINARY NOTES ON THE OCCURRENCE OF SERPENTINE AND TALC AT EASTON, PENNA.

F. B. Peck

[Plate XVI; text figures 4, 5]

(Read January 30, 1900)

The band of pre-Cambrian rocks which extends across the northern part of New Jersey in a southwesterly direction, crosses the eastern border of the State of Pennsylvania between Easton on the north and Kintnersville on the south. The band is here broken into a series of parallel ridges consisting chiefly of hornblende gneiss with intervening valleys of dolomites of post-Algonkian age.

The northernmost of these ridges is the southwestern extension of Scott's Mountain in New Jersey and crosses the Delaware river just north of Easton. On the Pennsylvania side of the river it is known as Chestnut Hill. Just across the river on the New Jersey side it is known as Marble Mountain.

Chestnut Hill is a rather sharp, even-crested ridge, having a maximum altitude of 700 feet above tide, and having a general trend of S. 60° W. It diminishes in altitude toward the southwest, and at a distance of four and one-half miles from the Delaware river disappears under the post-Algonkin dolomites. This, with two other similar ridges north and west of Bethlehem, twelve miles distant, constitutes the only recurrence of pre-Cambrian rocks in Pennsylvania north of the Lehigh River. A description of it as regards composition and structure will constitute the substance of this paper.

Chestnut Hill is composed of a dense hornblende gneiss with distinct bedding planes which dip at an angle of from 40° to 60° to the southeast. Interstratified in the gneisses are beds of car-

bonates of varying thickness (5 feet to 30 feet) consisting usually of a mixture of pink calcite and gray dolomite but occasionally consisting wholly of either the one or the other.

Hornblende (usually tremolite), phlogopite, and occasionally

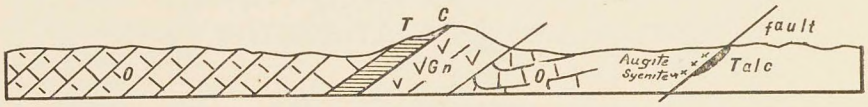


FIG. 4. Section No. I, taken along Bushkill Creek. *O* = Post-Algonkian dolomites; *T* = Tremolite beds presumably altered form of *C* which = calcite-dolomite beds; *Gn* = pre-Cambrian gneiss.

pyroxene occur so abundantly in these beds as locally to replace all or nearly all the carbonates, so that locally they become altered to a nearly pure tremolite rock with streaks or patches of phlogopite or pyroxene or containing at time considerable amounts of the original carbonates. These tremolite beds are confined to the southeastern slope of Chestnut Hill, and at the southwestern extremity of the ridge lie for the most part at or near the contact of the post-Algonkian dolomites on the pre-Cambrian gneisses. Here, as can be seen in the cut made by the Bushkill Creek, all three, viz., the dolomites, the tremolite beds and the pre-Cambrian gneisses dip uniformly to the southeast and are apparently conformable. (See **Fig. 4.**)

The explanation of the occurrence here of beds of tremolite would seem to be simple. In the first place the post-Algonkian dolomites are more or less silicious as the following analysis shows:

SiO_2	= 3.52	
Fe and Al	= 2.92	
$CaCO_3$	= 53.40	
$MgCO_3$	= 40.54	100.38

Immediately below them come the beds of carbonates which are usually highly dolomitic and may have contained original silica. Underlying these in turn are the pre-Cambrian gneisses which with their included quartz lenses and granite intrusions could furnish free quartz enough by infiltration to transform the beds

of carbonates over into silicates of lime and magnesia, and it is not impossible that the overlying post-Algonkian dolomites may have played some part in the formation of these tremolite beds. This process of transformation was doubtless greatly facilitated by dynamical forces resulting from faulting, as will appear later.

Into these, what we may term altered pre-Cambrian sediments, viz., the gneisses with their interstratified bed of carbonates, have been intruded in this limited area at least two kinds of eruptives.

The first and by far the most abundant is a coarse hornblende granite, which occurs in the form of lenses and bosses, the principal outcrop of which lies on the southeastern slope of Chestnut Hill just across the Delaware River from the southernmost extremity of Marble Mountain. It varies from a very coarse to a fine grained rock and is for the most part highly feldspathic, consisting almost wholly of orthoclase but containing varying amounts of quartz and an occasional blade of dark green hornblende. In the contact zone the hornblende predominates, replacing locally nearly all the quartz and feldspar.

The other eruptive, an augite syenite, occurs in much smaller quantities but presents some points of interest which had best be enumerated here. It appears as a much altered type in the serpentine-tremolite rocks, to be described later, lying in the northern part of the granite area above described. It appears again in the same manner in a series of dykes cutting across the beds of gneiss at the northern end of the Bushkill cut. Its principal occurrence, however, is at a point one-half mile east of Walter's Station on the Bushkill Creek, where some six distinct outcrops appear along an obscure fault (marked M. N.) which has the same trend as the gneiss ridge south of it. It occurs in the post-Algonkian dolomites and may have been intruded in the form of a dyke along which slipping subsequently took place, or it may have been faulted up from below.

Macroscopically the rock consists of an abundance of dark green augite with very little feldspar which gives the rock a very basic appearance. It is for the most part fine grained but is occasionally quite coarsely granular, almost granitoid in texture

and shows about equal amounts of feldspar and augite with a sprinkling of biotite scales.

In microscopic thin section the rock is seen to have as its most prominent constituent hypidiomorphic augite, having the peculiar green tinge of the soda bearing variety. On separation with Toulet's solution it gave the following analysis:

SiO_2	= 50.55	
FeO, Fe_2O_3	= 7.27	
Al_2O_3	= 8.66	
MgO	= 11.00	
CaO	= 19.70	
Na_2O	= 1.70	
K_2O	= .48	99.36

which shows an approach to an ægirine augite.[1]

The allotrimorphic feldspars, as a rule about equal in quantity to the augite, consist usually of microperthitic intergrowths of albite or oligoclase and orthoclase. The feldspars generally show a wavy extinction due to pressure and frequently the confused, patchy intercrystallization seen in many syenites containing nearly equal amounts of both soda and potash. On isolation the feldspars were shown by an alkali determination to contain 8.04% of potash and 4.55% of soda.[2] The last constituent of importance is biotite which in one locality quite replaces the augite and the rock thus becomes essentially a mica syenite. Magnetite occurs in but limited quantities. Long prisms of apatite are quite abundant in places and were as usual among the first crystals to form, being included in both the biotite and augite.

[1] This separation and analysis was made by Mr. Fred H. Moffit, post-graduate student in geology and assistant in chemistry in Lafayette College, Easton, Pa.

[2] This determination was also made by Mr. Fred H. Moffit.

An analysis of the rock as a whole gave the following:

SiO_2	=	53.58	
Al_2O_3	=	13.56	
Fe_2O_3	=	1.48	
FeO	=	4.75	
CaO	=	8.20	
MgO	=	8.93	
K_2O	=	2.37	
Na_2O	=	3.08	
P_2O_5	=	.17	
Mn^3O^4	=	.92	
H_2O	=	1.33	Sp. gr., 2.89.[1]
		98.37	

On comparing this with analyses of other syenites, it is found to contain about the average amount of SiO_2, to be low in Al_2O_3, but unusually high in magnesia and lime, having of the two together over 17%, while most syenites contain only from 2% to 6%. In this respect it resembles Weed and Pirsson's shonkonite of the Highwood Mountains, Montana. In general, however, it quite closely resembles some of the finer grained augite syenites of Norway, described by Professor Brögger as occurring in connection with the nepheline syenites of the Christiania region, for which reason perhaps it would seem natural to associate it genetically with the well-known nepheline syenite of Beemerville, N. J. A careful search for other occurrences of the rock in the region about has failed to discover it.

The serpentines and talcs of Chestnut Hill are all of them associated with a system of faults which follows the trend of the ridge. Within a distance of two miles north and two miles south of Easton there are four distinct thrust faults, all of them of types described by Mr. Bailey Willis in his "Mechanics of Appalachian Structure" as occurring in "The District of Folding and Faulting of Virginia, Tennessee and Georgia."[2]

[1] This analysis was made by Mr. Richard K. Meade, assistant in chemistry in Lafayette College, Easton, Pa.

[2] Thirteenth Annual Report, Part II, of the Director of the U. S. G. S. for the year '91–'92.

The first of these faults extends along the northwestern side of Marble Mountain and Chestnut Hill and constitutes the boundary line between the pre-cambrian and the post-Algonkian (**Plate XVI. *A-C.***). It is a typical break thrust fault. At *A* there is a branch fault given off which runs along the southeastern slope of Chestnut Hill to a point *B* where it appears to die out. It is along this branch fault *AB* which cuts, as it were, diagonally across the ridge that all the talc and serpentine deposits of the region, with one exception, occur.[1] It partakes here more of the nature of a stretched thrust and all of the rocks involved in the faulting are so sheared, stretched and profoundly altered as often to be recognized with difficulty. The granites, for example, have every particle of their feldspar constituent sheared into a stringy, almost fibrous variety of sericite, not a trace of the original feldspar remaining, while the quartz remains as lenticular or film-like patches but crushed almost to a powder. The hornblende alters for the most part to serpentine, in fact the richly hornblendic granites seem to furnish one source of serpentine. The calcite-dolomite beds shear to a slaty, foliated, talcose mass consisting of a mixture of talc, tremolite, serpentine, with occasional seams of tremolite (?) asbestos, imbedded in a fibrous carbonate of lime (aragonite?), the fibers of both minerals lying parallel to each other and normal to the walls of the seam; or without shearing, become changed to beds of nearly pure white tremolite. The phlogopite which is developed locally in large quantities in connection with these beds, sometimes in huge crystals a foot in diameter but usually in rather finely granular masses, alters quite uniformly to serpentine and constitutes the chief source of that mineral in the Easton quarries. Huge masses of it weighing many tons are removed from time to time, consisting quite wholly of phlogopite mica in different stages of alteration to serpentine. Locally these masses of phlogopite become changed to the very finest variety of "Royal" of "Victoria Serpentine" which occurs here in such abundance as to

[1] The principal occurrences of talc and serpentine are indicated by a widening of the fault lines along which they occur and quarries from which they have been taken are numbered 1–7.

rival the famous Connemara quarries of Ireland and excite the wonder of men of lifelong experience in the quarrying of decorative stones. One variation of this phlogopite serpentine is exciting considerable interest among architects. It consists of numerous rose-colored dolomite crystals scattered in masses of serpentine, which mixture when sawn and polished presents a most exquisitely beautiful combination of colors. This particular variety has been called "Verdolite" (Contraction of Verd-antique and dolomite), by Mr. William B. Read, president of the company now owning the quarries. This company, known as "The Verdolite Company," was formed for the purpose of purchasing and operating the quarries lying in the northern half of the granite area on the southeast slope of Chestnut Hill ridge and designated on the sketch map (**Plate XVI.**) as quarries No. 2, 3 and 4. These are the important quarries of the region. From No. 3 (Richard's quarry so called) is taken the best quality of serpentine. This quarry is directly on the highway and within two miles of the Lehigh Valley R. R. station. Between 3 and 4, a few hundred feet up the hill lie heavy ledges of verdolite and two or three hundred feet farther takes one into quarry No. 4 (known as Williams' quarry). This last named quarry has been excavated in a nearly pure tremolite rock which lies in heavy beds nearly 50 feet thick and dipping south under granite, which constitutes the hanging wall and lying on granite and gneiss to the northward. Evidently this rock has been faltered into its present position by thrusts from the south. The shearing to which it has been subjected has partially altered the tremolite to talc along the shearing planes, which rock has for years been quarried and ground for commercial purposes. Scattered through this finely crystalline, sometimes massive white tremolite rock, are seams and irregular aggregations of what was originally phlogopite or pyroxene, now altered thoroughly to a beautiful apple-green serpentine (Williamsite) which contrasts beautifully with the white tremolite. The relation of the tremolite to the serpentine and verdolite, in fact the relation and occurrence of all of the rocks under discussion, can be seen in Fig. 5 which is constructed along section line II. From fault line *AB* are given

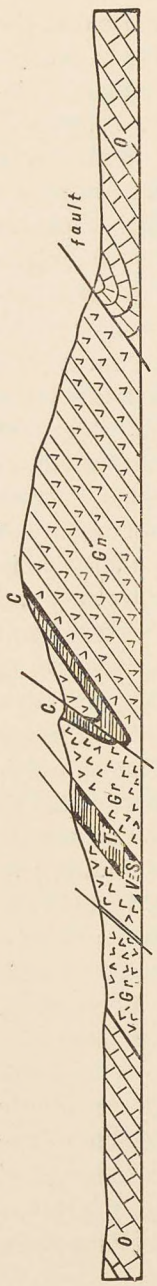


FIG. 5 Section No. II, taken diagonally across Chestnut Hill at its eastern end. *O* = Post-Algonquin dolomites; *gr* = granite; *T* = tremolite beds with included Verdolite (*V*) and Serpentine (*S*); *gn* = pre-Cambrian gneiss with interstratified calcite-dolomite beds (*C*).

off two well defined and a third more poorly defined branch faults which intersect the granite, along the northernmost of which occur quarries 3 and 4. Here as explained the tremolite (*T*) beds lie dipping to the south between two granite walls. Along both the hanging and the foot wall, in close proximity to the granite, have developed (by infiltration of silica from the granite?) large quantities of phlogopite, under the hanging wall mixed with pink dolomite and constituting verdolite (*V*), on the foot wall altered to royal serpentine (*S*). More or less serpentine is found scattered through the tremolite. The serpentine as usual is not continuous but occurs in irregular masses varying from a few pounds to many tons in weight.

One other occurrence of talc should be mentioned, viz., that at 6, along the northern boundary of the augite syenite. It lies on the fault M. N. and is developed on the contact of the augite syenite on the post-Algonkian dolomite. The best of it constitutes the finest quality to be found in the region. Its origin, as it would seem from the manner of its occurrence, is different from that at the other localities. Here the post-Algonkian dolomites seem to have been the rocks to suffer change, the augite syenite remaining perfectly fresh and unaltered throughout, while the change from talc at the contact outward towards the dolomite is a gradual one. With the exception of a few cubes of iron pyrites, the entire product of the metamorphosis here is talc, there being no serpentine and no tremolite.

One point more should be mentioned regarding the occurrence of the tremolite beds in the Anthony's Nose granite area. After the formation of the fault *AB*, which cut diagonally across the pre-Cambrian ridge, the two dislocated ends, viz., Chestnut Hill on the southwest and Marble Mountain on the northeast seem to have been thrust by each other along the fault plane *AB*, the tremolite beds as well as the Anthony's Nose granite on the southeastern slope of Chestnut Hill being made to override the under thrust end of Marble Mountain in a series of thrust faults by which the tremolite beds became faulted in between granite walls, while the tremendous shearing to which the rocks were subjected brought about the alterations which have been described. That there has been crustal shortening in a direction at right angles to the principal folding is shown by a series of more or less parallel faults running at right angles to the series already described. In the southern limits of the city of Phillipsburg are two thrust faults which hade to the east, and which bring the pre-Cambrian gneisses to the surface in two masses separated by about thirty feet of post-Algonkian dolomite. The Pennsylvania Railroad in traversing this mass has blasted all the way through in the dolomite, being the line of least resistance, and leaving either wall of the cut as gneiss. Two other faults cutting at right angles across the southwestern end of Chestnut Hill can be made out. The force producing this transverse series of faults could be called into requisition in explaining the thrusting by each other of the dislocated ends of the Chestnut Hill ridge and at the same time the curved branching thrusts which intersect the granite.

LAFAYETTE COLLEGE, EASTON, PA., January, 1900.

PLATE XVI.

PLATE XVI

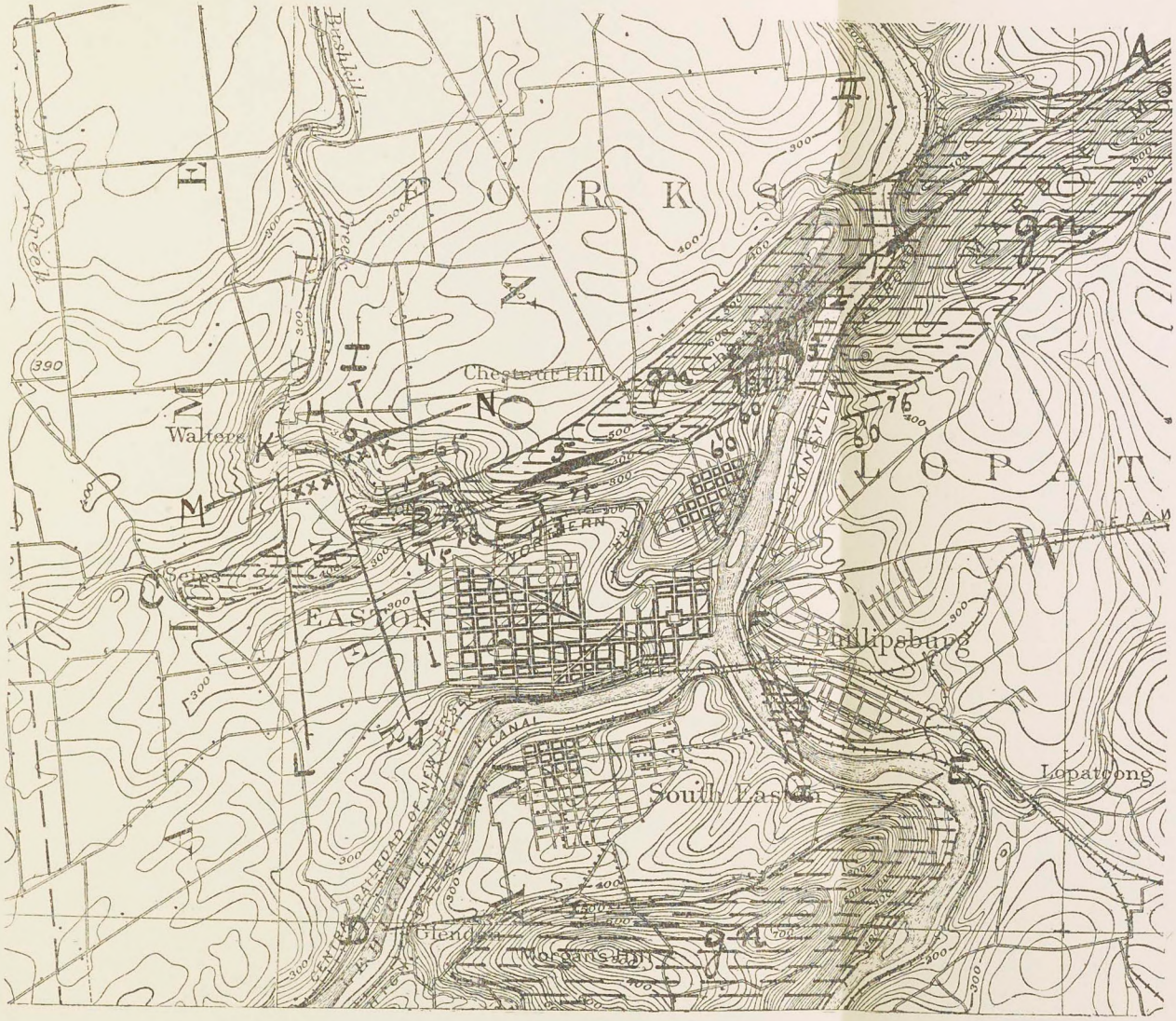
Sketch map of the vicinity of Easton, Penna., showing the occurrence of serpentine and talc and their relations to the main geologic features of the region.

gn = pre-Cambrian gneiss. gr = granite. xxx = augite syenite.

The principal occurrence of talc and serpentine are at points numbered 1 to 7 and are represented by thickenings of the fault lines.

A–B, etc., are fault lines.

I and II are lines along which sections are taken. See figs. 4 and 5 on pages 420 and 426 of text.



Scale $\frac{1}{62,500}$

1 ½ 0 1 2 3 4 Miles

Contour Interval 20 feet

Datum is mean Sea level